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BEE DEPARTMENT

By C. G. Butler

General

Lectures have again been given by several members of the department to Scientific Societies, Beekeepers' Associations and other organizations.

Members of the department have also taken a major part in conducting an Extension Course, arranged by London University, on "The Honeybee and some other Social Insects and their Allies".

Three members of the department attended the Fourteenth International Beekeeping Congress at Leamington Spa; and a successful three-day International Conference of bee research workers, the first of its kind, was organized and held at Rothamsted in September. More than 40 workers from 14 different countries attended this Conference.

During the year Mr. L. Bailey joined the scientific staff and has commenced work on Nosema disease. Miss G. R. Wykes has obtained her Ph.D. degree of London University. The Agricultural Research Council has extended their grant to Dr. Wykes to enable her to continue to work on problems of nectar secretion for a further year. Mr. J. B. Free, who also holds a grant from the Agricultural Research Council, has joined the staff to work on the behaviour of bumblebees, with particular reference to the pollination of red clover.

Dr. C. G. Butler has continued to serve on various Committees such as the Ministry's Bee Disease Advisory Committee, and their Honey Marketing Standards Committee.

During the summer a film illustrating the technique of instrumental insemination and bee breeding employed in the department, entitled "Breeding Better Bees", in which Dr. Butler, Mr. Simpson and Miss Carlisle took part, was made by Mr. C. P. Abbott. This film was first shown at the Fourteenth International Beekeeping Congress.

Bee Behaviour

General

Dr. C. G. Butler has now published the results of some of his work on the important part played by floral perfume in the discovery of both new and previously visited sources of food by the worker honeybee (129). He has been able to demonstrate that there is a natural tendency for untrained scouting bees to associate certain perfumes, such as those of the flowers of hawthorn and white clover, with food, whereas the perfumes of the flowers of some other species of plants, such as *Spirea arguta*, are either ignored by, or perhaps even repellent to, the honeybee.

Normally floral perfumes are rather weak and, since the acuity of the worker honeybee's sense of smell is similar to that of man (von Frisch, 1919), a foraging bee has to approach a flower very closely before she can appreciate its scent. If a honeybee is attracted towards an object, such as a real or an artificial flower, by its colour, pattern, movement and other characteristics, she exhibits a graded series of patterns of behaviour. At one end of the scale she merely departs from her characteristic searching, weaving, flight for a sufficient period of time to swerve down towards the object and inspect it more closely before continuing her flight as before. At the other end of the scale she settles on the object after some preliminary hovering and seeks food with extended tongue from any small crevice it may contain. In general the results of these investigations with both trained and untrained bees support the conclusions reached by Professor von Frisch in his work with trained bees, and indicate that, as a general rule, such floral characteristics as colour and pattern attract a bee from a distance, and that when the bee has made a close approach floral perfume stimulates her to make an even closer inspection. Sometimes, however, when the scent of a crop of flowers is really strong it does serve to attract bees from a distance under conditions in which the crop is invisible.

The nature of the behaviour that was observed probably explains the apparent temporary repellent effect to bees of certain insecticidal sprays when they are applied to open flowers on which the bees have been working.

Mr. C. R. Ribbands has, in collaboration with Dr. H. Kalmus of University College, London, also found that odours, but in this case odours produced by the bees themselves, play an important part in communication between honeybees that are visiting and seeking dishes of sugar syrup in the field. The results of this investigation are now being prepared for publication.

Mr. C. R. Ribbands has also been studying the question of colony organization and has shown that the age of honeybees is not the controlling factor in the determination of the division of labour amongst the worker bees of a colony. It was then postulated that food is the operative mechanism, on the ground that the total food supply of a colony determines the proportion of its workers which are required for each task. This hypothesis was tested, in collaboration with Mr. H. L. Nixon of the Plant Pathology Department, by means of experiments designed to measure, by the use of a radioactive tracer, the extent of food transmission within the colony. It was shown that this is very thorough and speedy, and it is considered to be sufficient to account for the division of labour. The results of this work are being prepared for publication.

Further studies on the foraging behaviour of individual honeybees have been made by Mr. Ribbands and Miss A. Speirs.

Dr. C. G. Butler, Mr. J. B. Free and Miss E. Tyndale-Biscoe have made a series of observations on the behaviour of guard and other bees of a colony at their hive entrance on the approach of robber wasps, robber bees from another colony, straying bees from another colony, and of other members of their colony. They have also studied the effect of the behaviour of those bees whose hive is being approached in this way on the behaviour of the wasps and various categories of bees mentioned. It is hoped that these results may perhaps throw some light on the problems involved in uniting colonies of bees and in queen introduction. A paper giving the results of these experiments is being prepared.

Egg laying, swarming, etc.

Miss E. Carlisle has made observations on the egg-laying activities of a queen honeybee throughout an eleven-week period from June to September. The distance covered by the queen, the frequency and duration of egg-laying, feeding and resting times were all noted throughout one- or two-hour periods, on consecutive or alternate days at first, and later twice a week. No system was apparent in the method of filling a comb with eggs: in one two-hour period during which 91 eggs were laid, the queen covered a large part of the comb in a random manner, and moved from one face to the other nine times, with six resting and feeding periods of three to eight minutes. Not until one comb was nearly filled with eggs did the queen move to another. When all the combs were nearly filled with brood or stores of food, the queen became either very agitated and moved actively from one to another seeking empty cells or else remained inactive for long periods before moving slowly for short distances.

Mr. J. Simpson has been making observations on the behaviour of the bees of a colony before and after swarming. A colony of bees that is about to swarm shows reduced activity in comb building, foraging and the rearing of brood. Queen cells are also present. The swarm from such a colony, although it consists entirely of bees from that colony and has the same queen as was present in the colony before swarming took place, immediately becomes fully active and does not rear further queen cells. Knowledge of the reasons for this change in behaviour is necessary for the understanding of the processes culminating in swarming. The act of swarming does not in itself bring about the change since if the swarm is returned to the parent colony it will usually emerge again in due course. The effect is likely therefore to be due to the separation of the bees of the swarm from something present in the colony from which they come. Preliminary experiments suggest that this factor is not connected with the queen cells, brood, food or combs. It would therefore appear to be connected with the adult bees in some way.

It seems probable that the production of queen cells by a swarming colony is due to factors similar to those which operate when a colony becomes queenless. This aspect of the problem is also being investigated.

Foraging of Wasps and Bumblebees

Dr. C. G. Butler and Miss E. Tyndale-Biscoe have examined the possibility that the workers of some of the common social wasps are able to communicate to one another within the nest information with respect to the position of particular sources of food. A considerable quantity of data were collected and all indicate that the species of wasps studied were unable to communicate with one another in this way. The data also indicate that carbohydrate forms an important part of the food supply of wasp colonies at all events during the late summer and early autumn, and, for example, that the same wasps will regularly visit a dish of sugar syrup and will give the syrup collected to other members of their colonies.

Mr. J. B. Free has been studying the foraging behaviour of several species of Bumblebees. He has obtained evidence which suggests that individuals of *Bombus terrestris*, *B. lapidarius* and *B. agrorum* may repeatedly return to forage on the same small area of a crop of red clover. When several nests of *B. agrorum* in which all the individuals were marked were placed in a red clover field, in no case was a worker seen at a greater distance than twenty yards from her nest. It is hoped that further work on the foraging areas of the different species will be possible. It has also been confirmed in experiments with artificial flowers that bumblebees prefer to visit those flowers which contain the most concentrated sugar solutions, as do honeybees. No evidence of communication of information between bumblebees has been obtained.

Nectar Secretion

Dr. Gwenyth Wykes has, with the assistance of Miss E. Carlisle, continued her survey of the nectars of the more important species of flowers visited by honeybees. Qualitative analyses of the sugars occurring in the nectars of about sixty different species have now been made. This investigation has shown that sucrose, glucose, and fructose, sugars which are highly attractive to bees, were present in the nectars of all but one of the species examined, and traces of maltose and two other rarer sugars were also found in certain species.

Since this exploratory work suggested that the relative proportions of the sugars in different nectars varied widely, and since such variations are likely to influence bee visits, a series of quantitative analyses of the sugars occurring in the nectars of some of the major honey-producing crops were made during 1951. It is hoped to extend this work during 1952.

Field observations have indicated that under certain conditions poor crops of fruit and seed may be due to inadequate pollination. This in turn could result either from the absence of sufficient pollinating insects or from shortage of available and attractive nectar in the flowers. Miss M. Ryle has, therefore, been conducting preliminary trials to test the effects of certain commonly used mineral fertilizers on the quantity of sugar secreted by the nectaries of various plants. In all cases the experiments were of factorial design with N, P and K each at two levels. With the kind permission of the Director of East Malling Research Station and the generous assistance of several members of his staff, it was possible to make observations on the nectar production of a set of apple trees which have been receiving differential manurial treatments for many years. Preliminary results suggested that trees receiving phosphate were producing more sugar per flower than those depending only on that which was initially present, but the difference was not significant. However, the observation will be repeated in 1952.

Sand culture experiments were also made using mustard, red clover and buckwheat as test plants and using N, P and K, at two levels. The results are now being analysed.

Physiology

Mr. L. Bailey has, as a part of his programme of work on Nosema disease, studied the physiology of pollen digestion by the honeybee. Pollen, taken as a suspension in honey by the bee, accumulates in the honey-stomach and is then filtered from its liquid medium to be passed into the ventriculus.

The precise mechanism of the filtration was observed by cutting out a small window over the site of the proventriculus in the abdomen of the anaesthetized bee, allowing the bee to recover and then feeding with a suspension of strained pollen. Observation of the proventriculus showed that it draws a small volume of suspension into its lumen and then expels the fluid back into the honey-stomach, retaining the pollen by means of the posteriorly directed combs of hairs and storing it in four pouches. When a large mass of pollen is collected by the organ, it is expelled posteriorly as a bolus into the ventriculus.

The rate of pollen filtration was determined and significant differences were noted with different suspensions of particles of different sizes and also with different volumes of suspension containing particles of the same size. Particles such as the spores of *Nosema apis* ($8\mu \times 3\mu$) were filtered with complete efficiency. A few similar observations on bumblebees and some solitary bees showed that the former were less efficient than the honey bee in filtering pollen and the latter could not filter pollen at all. These differences were accounted for by the study of the anatomical details of the proventriculi.

The proteolytic activity of the ventriculus of the honeybee was determined by its ability to digest gelatine. Its power of digestion was markedly reduced by the presence of honey even when the honey was adjusted to the same pH as the ventricular contents. This suggests that the filtration mechanisms of the proventriculus assists the digestion of pollen by the ventriculus by the exclusion of honey from the ventriculus until all the pollen has been filtered off. The pollen collects in the posterior half of the ventriculus as a compact mass, having been mixed with the proteolytic enzymes secreted by the ventriculus. Thus the enzymes are neither diluted nor inhibited by an excessive amount of honey.

It seems likely on the grounds given above, that solitary bees have not the same ability to digest pollen as have honeybees and this gives the honeybee two distinct advantages over the solitary bees: (1) Larval honeybees are fed with a prepared protein food from the pharyngeal glands of the adult bee. This ensures a diet more consistent in quality and quantity and more compact in volume than pollen. (2) The adult honeybee stores protein within its own body which may be instrumental in its ability to survive the winter and certainly provides a ready source of food for the larvae in the early part of the year when brood-rearing commences.

The ability of bumblebees to digest pollen is probably intermediate between that of the honeybee and solitary bee but the problem remains to be solved.

The relationships between the mechanics of pollen digestion and other physiological phenomena of the alimentary tract of the honeybee with the course of infection of the ventriculus by *Nosema apis* are now being studied.

Dr. C. G. Butler and Mr. J. Simpson have attempted to correlate the degree of activity of certain glands of the worker honeybee with her age and occupation. The proteolytic activity of the ventricular glands of different bees were found to be variable in early adult life 5-20 days of age), but consistently low in a few older bees (31 days of age) examined. The ventricular glands of bees feeding young brood were all found to have a greater degree of proteolytic activity than those of foragers. Comparison of this result with the data mentioned above showed that there were some bees as young as six days old which were almost certainly not feeding young brood and were probably foraging. The amount of invertase found in the pharyngeal glands of foraging bees was just significantly greater than that found in bee that were feeding young brood.

Both proteolytic activity and invertase content showed considerable variations in the bees examined.

Bee Breeding, etc.

The maintenance of several distinct strains of bees was continued by the use of instrumental insemination. Work is being continued on the development of syringes which are easier to use and to make.

Experiments have also been carried out on spring stimulation and an article on this subject has been published (130) ; on the effect of colony density in given areas on the size of the resulting honey yield ; and on various other aspects of practical beekeeping.

Publications

129. Butler (C. G.). 1951. *The importance of perfume in the discovery of food by the worker honeybee* (Apis mellifera, L.) (Proc. roy. Soc. B., **138**, 403-413.)

Worker honeybees have an inherent tendency to associate certain perfumes with food. This results in untrained scouting bees being attracted to certain kinds of flowers, such as hawthorn and wild white clover, which they have never visited before.

If the perfume of a crop of newly-opened flowers is sufficiently powerful, it sometimes attracts scouting bees from a considerable distance away. But, normally, a bee has to approach to within a few centimetres of a mouth of a flower before she can appreciate its perfume. If a bee has learned to associate a particular perfume with a particular group of flowers she will seldom enter any flower in the group unless she can smell its perfume.

When a bee is attracted towards a flower or flower-like object and approaches it closely, any attractive perfume it may possess tends to act as a stimulus to further exploration which may involve settling on the object and possibly extending her tongue and seeking food in any small crevice in or around the object.

In general, the results obtained with untrained bees support the conclusions reached by von Frisch in 1919 in his work with trained bees, and suggest that both of these categories of bees behave in a similar way when seeking food.

130. Butler (C. G.). 1951. *Beekeeping and agriculture.* (Brit. agric. Bull., **4** (16), 236-241.)

A discussion of the part played by honeybees in the pollination of fruit and seed crops, and of the way in which recent advances in bee research have made it possible for beekeepers to co-operate with fruit and seed growers more effectively than in the past.

131. Ribbands (C. R.). 1951. *The flight range of the honeybee.* (J. Anim. Ecol., **20**, 220-226.)

The gains in weight of groups of colonies sited on the edges of crops were compared with those of groups of colonies sited $\frac{3}{8}$ and $\frac{3}{4}$ mile away from the same crops.

The chief crops chosen were apple, lime and heather ; the experiments were repeated in two successive years. The effect of increased flying distance was large, and increasingly detrimental, but the magnitude of the effect varied considerably. Most of the effect was a consequence of unfavourable weather. The result illustrates a disadvantage of placing large numbers of colonies in one apiary.

132. Wykes (G. R.). 1951. *Selection of certain nectars by honeybees.* (Ann. Rep. Cent. Assoc. British Beekeepers' Assoc.)

A discussion of various factors which affect the taste perception of honeybees and their selective nectar gathering behaviour when foraging.